

Meta-Analysis of Problem Based Learning Models Impact towards of Problem Solving Skills in Physics Learning

Nur Siyaadatul Ummah¹, Ayunin Nadzirin¹, Fithriatiz Zahro¹, Binar Kurnia Prahani^{1*}, Joko Siswanto², Husni Mubarak³, Abestayehu Yohannes⁴, Yuli Sutoto Nugroho⁵, Jauharoti Alfin⁶

¹Universitas Negeri Surabaya, Surabaya, Indonesia

²University of PGRI Semarang, Semarang, Indonesia

³National Taiwan University of Science and Technology, Taipei, Taiwan

⁴Wolaita Sodo University, SNNPRegion, Ethiopia

⁵Queen Mary University of London, London, England

⁶UIN Sunan Ampel Surabaya, Surabaya, Indonesia



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ABSTRACT

Objective: This study is to analyze problem-based learning models' effect towards skills of problem solving in learning Physics. Problem based learning in physics learning can trigger students to participate in the teaching and learning process actively. It can motivate students to increase interest in scientific problems that occur and simultaneously stimulate skills in solving scientific problems. **Method:** used in this study is meta-analysis, namely by conducting a literature review of 15 scientific articles that several national and international journals have published regarding problem-based learning models impact on skills of problem solving published from 2018 to 2022. **Results:** Results of this research are a problem-based learning model that has a significant impact on improving problem solving skills in learning Physics. So, problem-based learning model able to be implemented in learning Physics to enhance problem solving skills. **Novelty:** Novelty of this research is a type of scientific article that is used not only published by national journals but also published by international journals published from 2018 to 2022.

INTRODUCTION

Education is one way to improve a country's human resources. Education is also one of the indicators of progress or not of a country. The Indonesian government is trying to make Indonesia a developed country by advancing education in Indonesia. Education in the 21st century is increasing, so students are expected to have 21st-century skills, namely critical thinking, creativity, communication, and collaboration. One example of a form of essential thinking skill is solving problem skills. Skills of problem solving should be taught from childhood, so they are accustomed and trained to solving every problem in everyday life.

One of the subjects that have the essential characteristics of thinking in solving problems built through scientific investigation is Physics. According to Astutik (2021), to integrate Physics subject with 21st-century skills, we need a learning model which triggers students to become active in teaching and learning activities. Meanwhile, according to Prayogi (2020), there are several choices of learning models that teachers can use in teaching and learning activities, including project-based learning, problem based learning, and cooperative learning. According to Phasa (2020), in learning Physics, many teachers have implemented problem based learning towards learning Physics. By means of problem based learning, students learn concepts related to problems and understand concepts relevant to education topics (Suhardiman, 2021). Teaching and learning

activities that use a model of problem based learning can trigger curiosity of students and motivate students to improve their skills in solving scientific problems.

Many studies have discussed problem based learning effect towards skills of problem solving in Physics learning, including study results Aulia (2022) said that problem based learning model can be applied so that students are triggered to learn so that solving skills Physics problems that students have an increase in the material effort and energy. Meanwhile, according to Ekasari, et al (2018), problem solving skills regarding heat implemented using problem based learning significantly increased; addition, problem solving skills which include the stage of defining the problem, problem schema, understanding relationships casual in trouble, argument for studying problem solving, as well as analyzing problems also experienced a significant increase. Sarkity, et al (2018) concluded that problem based learning could increase problem solving skills on regarding style moment. According to Sumardiana & Rasyidi (2021), problem-solving skills are owned by students on legal topics Archimedes, Which implemented with learning-based the problem experienced an increase significantly. Research conducted Yuberti, et al (2019) stated that an influence model uses context and problem based learning towards skills of problem solving in Physics learning. Context and problem based learning model is effective in improving Physics problem solving skills, and according to Dwi & Napitupulu (2018), solving skills in Physics problems that students have been taught use model problem based learning is better than conventional learning. Meanwhile, according to Kertinus, et al (2019), the ability to understand concepts and problem solving skills possessed by students use problem based learning better than the learning model conventions in legal matters Archimedes. Simanjuntak and Rugaya's research (2019) concluded that there are differences due to problem based learning model impact on skills of problem solving's students on the subject matter effort and energy.

Several studies also integrate specific strategies in implementing problem based learning on skill of problem solving in Physics learning. Research conducted by Prahani (2022) concluded that online problem based learning assisted by digital book applications use 3D animation learning tools can improve students' skills of problem solving in magnetic field material. Research by Abdjul (2021) concluded that there is a significant influence on the implementation of Microsoft Teams on skills solving problems that students have by using problem based learning model, which is the application of Microsoft Teams as a media in learning later with using learning problem based learning model in learning process is something suitable to be integrated into working on solving skills student problem. In their research, Siboro (2021) proved that there was a significant influence on problem based learning with PhET-assisted against Physics problem-solving ability on the subject matter of elasticity and Hooke's law. Wisic & Makiyah research (2021) concluded that using learning modules in material-based rotation dynamics problem based learning can improve skills of problem solving possessed by students. The study conducted by Diana and Makiyah (2021) concluded that LKPD is based on problem based learning on learning. Physics can improve problem solving skills on double-slit interference material.

Meanwhile, according to Susanto (2018), there is an excellent influence on problem based learning with experimental assistance skills of Physics problem solving on the subject matter of measurement. Meanwhile, according to Hindriyani, et al (2020), problem based learning is accompanied by formative assessment gives better results on problem solving skills in circuit material of direct current. Besides, problem based learning accompanied by assessment of formative strongly impacts and positively influences current circuit problem-solving skills.

Based on the studies above, the problem-based learning model has an influence on problem-solving skills in physics learning, but to find out more specifically the effect size value of the effect of the problem-based learning model on problem-solving skills in physics learning, it is necessary to analyze and research articles that have been published in various credible scientific journals. Referring to this statement, **the research problem** in this study is the effect size of the problem-based learning model on problem-solving skills in physics learning. This research uses the meta-analysis method. According to Retnawati et al. (2018), meta-analysis is research that uses existing articles and has been used by researchers and is carried out systematically and quantitatively to obtain accurate conclusions.

Research novelty of this meta-analysis research are: (1) scientific articles that are reviewed not only from national journals but also international journals; (2) finding out the value of the effect size using two types of formulas, namely *Cohen's d* and *eta square*; and (3) the number of articles reviewed are 15 scientific articles published from 2018 to 2022. Based on the description, this study aims to determine effect size of the problem-based learning model has on problem-solving skills in physics learning.

RESEARCH METHOD

This research design uses meta-analysis by conducting a literature review of scientific articles that several journals have published regarding problem based learning impact towards skills of problem solving published from 2018 to 2022. Flow of meta-analysis, first to determine the title of study, second to determine criteria for scientific article to be searched for, third to search for articles on Google Scholar, fourth to get 15 scientific articles that, according to the criteria, the fifth analyzed the 15 scientific articles that had been obtained, and the sixth concluded the meta-analysis data. For more details about the flow of meta-analysis research, it can be seen in the following flowchart.

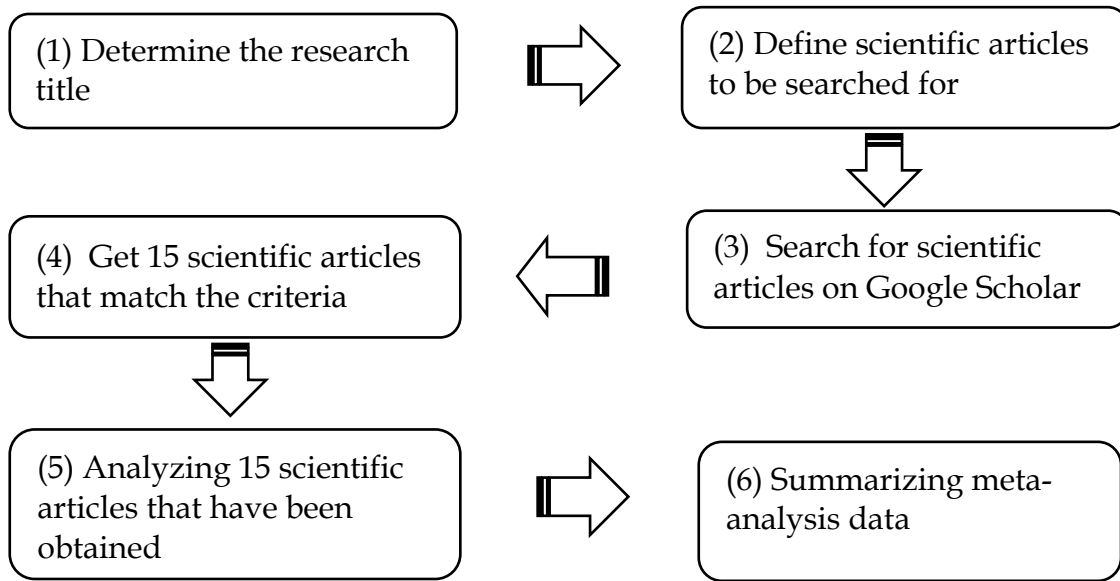


Figure 1. Meta-analysis research flow

$$\eta^2 = \frac{t_0^2}{t_0^2 + d_b} \quad (1)$$

(Kadir, 2017)

Information

η^2 = value effect size (eta square)

t_0 = t count

d_b = degrees of freedom

Next is the calculation result effect size, obtained from the formula eta square (η^2) calculation, which will be interpreted into a criterion made by Gravetter and Wallnau (Anadiroh, 2019) in Table 1.

Table 1. Category of effect size according to Gravetter and Wallnau

Effect size	Category
0.01 - 0.09	Little effect
0.09 - 0.25	Medium effect
> 0,25	Big effect

The second formulation is to find out effect size with uses the formula Cohen's d. Here is the summary

$$ES = \frac{\bar{X}_s - \bar{X}_c}{SD_{pooled}} \quad (2)$$

$$ES = \sqrt{\frac{(n_e - 1)SD_e + (n_c - 1)SD_c}{n_e + n_c - 2}} \quad (3)$$

Information

ES = Value effect size (Cohen's d)

\bar{X}_e = Average value of the experimental class

\bar{X}_c = Average value of the control class

SD_{pooled} = Combined value of standard deviations

SD_e = Experimental class standard deviation

SD_c = Control class standard deviation

n_e = The participants number in class of experimental

n_c = The participants number in class of control

The calculation results in effect size, which is obtained from the formula Cohen's d calculation. It will be interpreted into a criterion made by Cohen, Manion, and Morrison (2018) in Table 2.

Table 2. Category effect size (Chosen, Manion, dan Morison, 2018)

Effect size	Category
0.00 - 0.20	Twiggy effect
0.21 - 0.50	Nether effect
0.51 - 1.00	Medium Effect
> 1.00	Great Effect

RESULTS AND DISCUSSION

Results

The search results for scientific articles that match the specified criteria regarding problem-based learning impact towards solving problem skills in Physics learning obtained 15 scientific articles published in the range of 2018 to 2022. The following 15 scientific articles used data in meta-analysis research in Table 3.

Table 3. Scientific articles used in meta-analysis research

No	Data Code	Research Title	Researcher Name	Publication Year	Journal
1	PM 1	Implementation of Online Problem Based Learning Assisted by Digital Book with 3D Animations to Improve Student Physics Problem-Solving Skills in Magnetic Field Subject	1. Binar Kurnia Prahani 2. Iqbal Ainur Rizki 3. Khoirun Nisa 4. Nina Fajriyah Citra 5. Hanan Zaki Alhusni 6. Firmanul Chess Wibowo	2022	Journal of Technology and Science Education

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No	Data Code	Research Title	Researcher Name	Publication Year	Journal
2	PM 2	The Effect of Problem Based Learning Models on Students' Physics Problem Solving Ability on Business Material and Energy	1. Izzatul Muna Aulia 2. Hikmawati, & Susilawati	2022	Journal of Physics and Technology Education (JPFT)
3	PM 3	Improving Problem-Solving Ability of SMAN 1 Gondang Students on Calor Material with Problem Based Learning	1. Aprilita Ekasari 2. Markus Diantoro 3. Steamy	2018	Education Journal
4	PM 4	The Effect of Using Microsoft Teams on Students' Problem-Solving Ability Using Problem Based Learning Models on Harmonic Vibration Material	1. Indrawan Hermanto Abdul Jahja 2. Mohamad Abd Wahidin Nuayi 4. Asri Arbie	2021	Jambura Physics Journal
5	PM 5	The Effect of the PhET-assisted PBL Model on the Ability to Solve Physics Problems in the Subject Material of Elasticity and Hooke's Law of Class XI Semester I Students of SMA Muhammadiyah 18 Sunggal	1. Asiroha Siboro 2. Jelita Pandjaitan 3. Julian Gull Hari Napolna Siboro	2021	Physicist Research Journal
6	PM 6	The Effectiveness of Problem Based Learning Modules on Students' Problem-Solving Ability in Rotational Dynamics Material	1. Mega Ilyasa Wisic 2. Yanti Sofi Makiyah	2021	Orbita. Journal of Study Results, Innovations, and Applications of Physics Education
7	PM 7	Student Ability in Solving Style Moment Problems through Problem Based Learning	1. Dios Sarkity 2. Lia Yuliati 3. Arif Hidayat	2018	Education Journal

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No	Data Code	Research Title	Researcher Name	Publication Year	Journal
8	PM 8	The Effectiveness of Student Worksheets (LKPD) Based on Problem Based Learning (PBL) Models to Improve Problem-Solving Skills in Double Slit Interference Material	1. Diana numbers 2. Yanti Sofi Makiyah	2021	Journal of Physics Education
9	PM 9	Analysis of Problem-Solving Ability with Problem Based Learning Material on Archimedes' Law	1. Sumardiana 2. Dear Rashidi	2021	Nusra: Journal of Research and Education
10	PM 10	The Effect of the Experiment-Assisted Problem Based Learning Model on the Ability to Solve Physics Problems on Quantity and Measurement	Irwan Susanto	2019	Journal of Education Research
11	PM 11	Approaching Problem Solving Skills of Momentum and Impulse Phenomena Using Context and Problem Based Learning	1. Yuberti 2. Sri Latifah 3. Aditya Anugrah 4. Antomi Saregar 5. Misbah 6. Kittisak Jermisitti parsed	2019	European Journal of Educational Research
12	PM 12	Improving Students' Ability in Solving Physics Problems through Problem Based Learning Models	1. Dara Fitrah Dwi 2. Safrida Napitupulu	2018	MIPA Education Research Journal
13	PM 13	The Effect of Problem Based Learning on Conceptual Understanding and Problem-Solving in Archimedes' Law Material	1. Rough Kertinus 2. Yudi Dharma 3. Wahyudi	2019	Education: Journal of Education
14	PM 14	The Effect of the Problem Based Learning Model on Students' Problem-	1. Elfrida Maharani Simanjuntak 2. Rugaya	2019	Journal of Physics Learning Innovation

No	Data Code	Research Title	Researcher Name	Publication Year	Journal
15	PM 15	Solving Ability in the Main Material of Business and Energy in Class X Semester II SMAN 9 Medan Ability to Solve Problems of Direct Current Circuits in Problem Based Learning accompanied by Formative Assessment	1. Ari Hindriyani 2. Sentot Kusairi 3. Lia Yuliaty	2020	Education Journal

The 15 scientific articles presented in table 3 are then grouped into two groups based on how to analyze them, namely by using Cohen's d and eta square calculations. The following is results of analysis size effect table using Cohen's d calculations.

Table 4. Results of Analysis in Size Effect using Calculations of Cohen's d

Data Code	Effect Size	Category
PM 1	1,95	High effect
PM 2	1,14	High effect
PM 3	1,66	High effect
PM 6	3,19	High effect
PM 7	0,9	Moderate effect
PM 8	1,21	High effect
PM 9	5,08	High effect
PM 12	0,77	Moderate effect
PM 13	3,42	High effect
PM 15	1,69	High effect
Average	2,10	High effect

The following is a graph of the results of analysis size effect using Cohen's d calculations

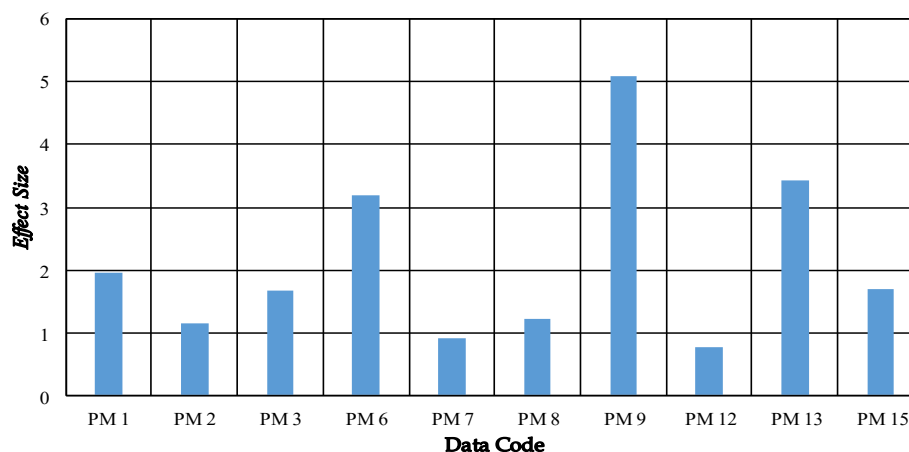


Figure 1. Results of analysis in size effect using Cohen's d calculations

The following is a table of the results of the analysis using calculations eta square

Table 5. Analysis results effect size using calculations eta square

No	Data Code	Effect Size	Category
1	PM 4	0.65	Big effect
2	PM 5	0.14	Medium effect
3	PM 10	0.20	Medium effect
4	PM 11	0.22	Medium effect
5	PM 14	0.45	Big effect
	Average	0.33	Big effect

The following is a graph of the analysis results effect size using calculations eta square.

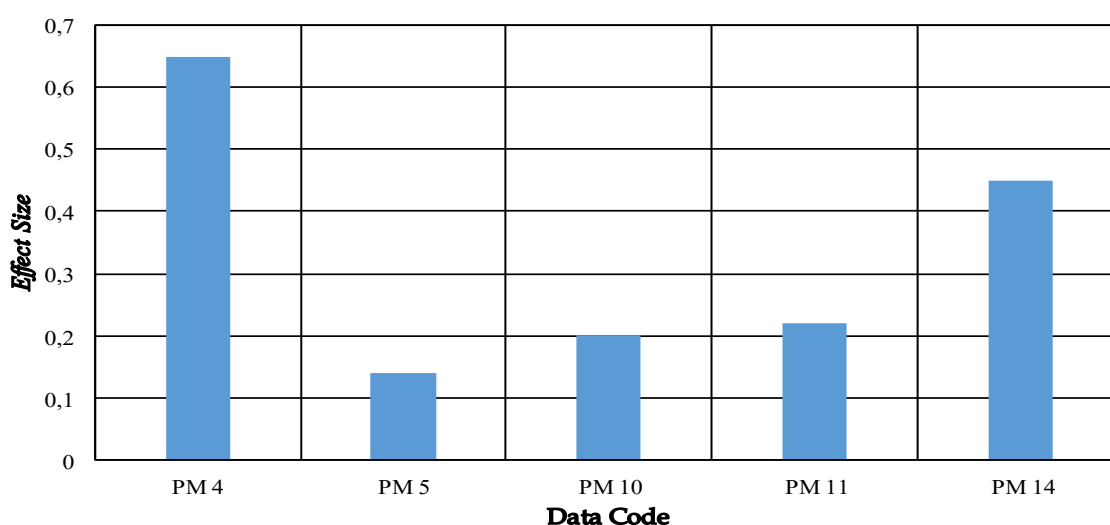


Figure 2. Analysis results effect size using calculations eta square

Discussion

Based on the results of data analysis in table 4 and figure 1, it shows that the effect size of the problem-based learning model on problem-solving skills in physics learning varies in its effect size category. Two articles have a moderate effect size, namely articles from research conducted by Sarkity, D., Yuliati, L., and Hidayat, A. (2018), whose effect size value is 0.90, and research conducted by Dwi, D.F., and Napitulu, S. (2018), whose effect size is 0.77. Even though the effect size value is in the moderate category, it can still be said that the problem-based learning model has quite an influence on problem-solving skills in physics learning. Eight articles have a high effect size category, namely articles from research conducted by Prahani, B.K., et al. (2022) the effect size is 1.95; research conducted by Aulia, M.I., Hikmawati, & Susilawati (2022) the effect size value is 1.14; research conducted by Ekasari, A., Diantoro, M., & Parno (2018) the effect size value is 1.66; research conducted by Wisic, M.I., Makiyah, Y.S. (2021) the effect size is 3.19; research conducted by Diana, R., Makiyah, Y.S. (2021) the effect size is 1.21; research conducted by Sumardiana & Rasyidi, M. (2021) the effect size value is 5.08; research conducted by Kertinus, R., Darma, Y., Wahyudi (2019) the effect size value is 3.42; and research conducted by Hindriyani, A., Kusairi, S. & Yuliati, L. (2020) the effect size value

is 1.69. Furthermore, the effect size value of each article is accumulated and averaged to produce an average effect size value of 2.10. The average of 10 scientific articles, after being calculated using Cohen's d calculations, has a high effect size. These results indicate that there is a high influence of the problem-based learning model on problem-solving skills in learning physics.

Referring to the results of data analysis in table 5 and figure 2, it proves that the effect size of the influence of the problem-based learning model on problem-solving skills in physics learning has various effect size values. Two articles have a large effect size, namely articles from research conducted by Abdjul, I.H., et al. (2021), whose effect size value is 0.65, and research conducted by Simanjuntak, E.M., and Rugaya (2019), whose effect size value is 0.45. Three articles have a moderate effect size, namely articles from research conducted by Siboro, A., et al. (2021), where the effect size is 0.45; research conducted by Irwan, S. (2019), where the effect size value is 0.20; and research conducted by Yuberti, et al. (2019), where the effect size value is 0.22. Even though the effect size value is in the moderate category, it can still be said that the problem-based learning model has quite an effect on problem-solving skills in physics learning. Furthermore, the effect size value of each article is accumulated and averaged to produce an average effect size value of 0.33. On average, five scientific articles, after being calculated using the eta square calculation, have a large effect size. These results indicate that there is a large influence of the problem-based learning model on problem-solving skills in learning physics.

CONCLUSION

Fundamental Finding : Fundamental findings in this study are based on the results and discussion of this meta-analytic research. It can be concluded that the model problem based learning significantly influences problem-solving skills in Physics with grades effect size an average of 2.10 using calculations Cohen's d , while the average value effect size using calculations eta square is 0.33 with the category of having a significant effect. This study implies that problem based learning model can be applied in physics to improve problem-solving skills in everyday life. **Limitation :** Limitations in this study are the first, the number of articles analyzed regarding problem based learning impact towards problem solving still needs bigger, namely 15 articles, and the second is that there are still few articles published in international journals. **Future Research :** Future research is hopefully, results this study can be used as recommendation for teachers to conduct other research that has the same topic, namely impact of problem based learning towards problem solving skills, besides that it can used as reference for other study so that the following study is more detailed and complete.

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Nur Siyaadatul Ummah

Department of Physics, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Ketintang, Kec. Gayungan, Surabaya, Jawa Timur 60231
Email: nur.20019@unesa.ac.id

Ayunin Nadzirin

Department of Physics, Faculty of Mathematics and Natural Science,
State University of Surabaya, Jl. Ketintang, Surabaya 60231, Indonesia
Email: ayuninnadzirin.20020@mhs.unesa.ac.id

Fithriatiz Zahro

Department of Physics, Faculty of Mathematics and Natural Science,
State University of Surabaya, Jl. Ketintang, Surabaya 60231, Indonesia
Email: fithriatizzahro.21014@mhs.unesa.ac.id

***Dr. Binar Kurnia Prahani (Corresponding Author)**

Department of Physics, Faculty of Mathematics and Natural Science,
State University of Surabaya, Jl. Ketintang, Surabaya 60231, Indonesia
Email: binarprahani@unesa.ac.id

Dr. Joko Siswanto

Department of Physics, Faculty of Mathematics and Natural Science,
Universitas PGRI Semarang, Semarang Indonesia
Email: jokosiswanto@upgris.ac.id

Husni Mubarok

Graduate Institute of Digital Learning and Education, National Taiwan University of
Science and Technology
No. 43 號, Section 4, Keelung Rd, Da'an District, Taipei City, 106 Taiwan
Email: husnimubarok254@gmail.com

Abebayehu Yohannes

Department of Mathematics, College of Natural and Computational Science, Wolaita Sodo University
Wolaita Sodo, SNNP Region, 138 Ethiopia
Email: abex98@gmail.com

Yuli Sutoto Nugroho

School of Electronic Engineering and Computer Science, Queen Mary University of London
Mile End Road, London E1 4NS, England
Email: y.nugroho@qmul.ac.uk

Jauharoti Alfin

Primary Education, UIN Sunan Ampel Surabaya
Jl. Ahmad Yani No.117, Jemur Wonosari, Kec. Wonocolo, Kota Surabaya, Jawa Timur 60237
Email: alfin@uinsby.ac.id
